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FOR

WIDE AREA NETWORK MOBILITY FOR IP BASED NETWORKS

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Wide Area Network Mobility for IP Based Networks

BACKGROUND

Applicants' invention relates generally to IP based networks and, more particularly, to mobility between IP based networks.

Fixed data networks, such as the Internet, have conventionally been used for the communication of digital data between different nodes in the network. With the increasing use of mobile nodes, however, such as portable notebook computers, fixed data networks have often become disadvantageous due to the lack of connections to the fixed data network at any specific location to which a mobile node might roam. To solve this problem, data communications using mobile communications system have been implemented to provide mobility for mobile nodes. Such mobile data communications systems typically involve packet radio systems such as General Packet Radio Services (GPRS) or Cellular Digital Packet Data (CDPD) that use IP based protocols. These packet radio systems advantageously permit a mobile node to roam within a cellular network while retaining the ability to initiate data communications at any location within the network.

Mobility in data communications is, however, problematic when a mobile node moves across cellular networks. Thus, if a mobile node moves from a first network to a second network data communications may be lost. For example, in a GPRS system, inter-GGSN (Gateway GPRS Serving Node) communication is currently not defined and, thus, data packets will be lost because a tunnel cannot be established to reroute data packets to the new Serving GPRS Serving Node (SGSN) in the second network from the old SGSN/GGSN in the first network. Seamless data communication with a mobile node, when the mobile node roams between two heterogeneous packet data networks, thus cannot be achieved using current IP based protocols.

SUMMARY

It is thus an object of the invention to achieve seamless data communication between two IP based packet networks when a user travels from an area serviced by a first data packet network to an area serviced by a second data packet network.

In accordance with a first exemplary embodiment, a method of keeping a session active and connected while changing data communications networks is provided. The method of this exemplary embodiment comprises the steps of: receiving packets, associated with a session, over a first connection in a first data communications network; requesting a second connection with a second data communications network while moving towards the second network; acquiring an address of a gateway associated with the second data communications network, wherein said steps of requesting and/or acquiring use an unsolicited connection procedure; and routing packets, associated with said session, over the second connection based on the acquired gateway address.

In accordance with a second exemplary embodiment of the invention, a method of keeping a session active and connected while changing data communications networks comprises the steps of: receiving packets, associated with a session, from a first data communications network; moving to a second data communications network; selecting a preferred gateway in the second data communications network; initiating an unsolicited connection procedure in the second network for a second connection, wherein said connection request includes an address of a gateway associated with said first network; forwarding packets, associated with said session, to said preferred gateway through said connection procedure; and receiving said forwarded packets from said preferred gateway over said second connection.

In accordance with a third exemplary embodiment of the invention, a method of keeping a session active and connected while changing data communications networks comprises the steps of: receiving packets, associated with a session, from a first data communications network; sending routing information from a gateway in said first network to one or more gateways in neighboring data communications networks using an unsolicited connection procedure; establishing a connection between user equipment and

a second gateway, said second gateway being one of said one or more gateways in the neighboring data communications networks that is associated with a target cell; forwarding packets, associated with said session, from said gateway in said first data communications network to said second gateway; and receiving, in the user equipment, said forwarded packets from said second gateway.

In accordance with a fourth exemplary embodiment of the invention, a method of keeping a session active and connected while changing data communications networks comprises the steps of: receiving packets, associated with a session, from a first data communications network; sending a request for access, from user equipment receiving said packets, to a second data communications network; initiating an unsolicited connection procedure to a gateway in said second data communications network; returning an address of the gateway in the second data communications network to said user equipment; sending said address to a gateway in said first data communications network; forwarding packets, associated with said session, from said gateway in the first data communications network to said gateway in the second data communications network using said address; and receiving, at said user equipment, the forwarded packets from said gateway in said second data communications network.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects and advantages of the invention will be understood by reading the following detailed description in conjunction with the example drawings in which:

FIGs. 1-3 illustrate flow diagrams of method steps in accordance with exemplary embodiments of the invention;

FIG. 4 is a flow diagram of a detach procedure in accordance with another exemplary embodiment of the invention;

FIGs. 5-7 illustrate system diagrams showing messaging in accordance with exemplary embodiments of the invention;

FIGs. 8-11 illustrate flow diagrams of method steps in accordance with a further exemplary embodiment of the invention;

FIG. 12 illustrates a system diagram showing messaging in accordance with an exemplary embodiment of the invention; and

FIG. 13 illustrates a flow diagram of an exemplary terminal assisted handover process.

DETAILED DESCRIPTION

Seamless data communication can be achieved in exemplary embodiments of the invention through modification of the communication protocol to enable the implementation of inter-packet network roaming. In exemplary embodiments, inter-network roaming is provided at the gateway level (example of gateways: H.323 GW, GPRS gateway, MobileIP Foreign Agent, etc.), where the gateway for the network from which a user has roamed, and the gateway for the network that the user has roamed into, are inter-operable either directly or through another gateway or proxy. To achieve inter-packet network roaming, exemplary embodiments allow a request for handover resources, using a new method named as an unsolicited connection procedure, in the network into which the user is roaming (the target network) to be initiated either by the current serving network, the target network, or by user equipment (e.g., user terminal).

The request for hand-over resources in the target network may thus be achieved in exemplary embodiments using three different techniques: 1) serving network initiated handover (SNH), where the gateway in the serving network broadcasts to possible candidate handover gateways using measurement reports provided by the user equipment; 2) target network initiated handover (TNH), where the user equipment requests the target network to notify the current serving network that the user has moved from the network and further requests that packets be forwarded to a new gateway address; and 3) terminal assisted handoff (TAH), where the user equipment performs handoff measurements, requests resources from the target network, and then forwards the information uplink to the current serving gateway which then sets up a communication path with the target gateway as supplied by the user equipment.

An exemplary GPRS based method of re-routing an established session to user equipment, when the user roams from a routing area administered by a first network to a

routing area administered by a second network, is illustrated in Figures 1-4 and 13, with associated system messaging shown in Figures 5-7. Beginning with Figure 1, the user equipment first acquires **100**, through possibly modified mobility management procedures, the address of the current serving GGSN ($GGSN_1$) that may subsequently be included in the optional information element contained in the PDP context accept message. This address may be acquired through messages broadcast (**500**; Figure 5) on downlink control channels before the user equipment first initiates a session in the first network.

At step **110**, measurements of necessary signal quality in the current and neighboring cells are performed, using conventional techniques, as the user equipment roams throughout the current network. If serving network initiated handover is used, then step **110** of Fig. 1 proceeds to step **305** of Fig. 3 (See "Serving Network Initiated Handover" section below). If either target network initiated handover, or terminal assisted handover are used then the process proceeds to step **115** of Fig. 1. An evaluation **115** of the signal quality measurements is further performed in accordance with conventional techniques to select a target cell for hand-off in the event the user equipment roams from the edge of the current cell into a neighbor cell. The $SGSN_1$ (**530**; Fig. 5) then can determine **120**, using a local database containing roaming information, that the candidate target cell resides in a network that is external to the current serving network. If the target cell resides within the current serving network, conventional routing procedures are initiated **125**. If, however, the target cell does reside in an external network (implying inter-gateway handoff), a re-routing procedure in accordance with the exemplary embodiments is performed.

Two alternative techniques can be used for re-routing the data to the user equipment in the candidate network. In a first technique (TNH), where the target network initiates handover of the data communication, $GGSN_1$ begins forwarding the buffered packets after being contacted by the GGSN in the external network ($GGSN_2$). In a second technique (TAH), where the user equipment initiates handover, $GGSN_1$ begins forwarding the buffered packets when the user equipment supplies the address of $GGSN_2$.

A GPRS system has been used to illustrate the different techniques (TNH, SNH, TAH) for re-routing data. Other systems, however, can easily use these techniques to provide wide area network mobility.

Target Network Initiated Handover (TNH)

Following the acquisition **100** of the current GGSN by the user equipment (as shown in Fig. 1), an exemplary GPRS based target network initiated handover process can be performed, as illustrated in Fig. 2. In this exemplary process, the user first roams into the target cell before the user equipment initiates **210** a routing area update to the SGSN serving the target cell ($SGSN_2$). This routing area update can optionally include the address of $GGSN_1$ (**535**; Fig. 5) in the current serving network or other parameters such as the Routing Area ID (specified in ETSI GSM 03.60) and session parameters. $SGSN_2$ (**550**; Fig. 5) then initiates **215** an unsolicited PDP context request (**520**; Fig. 5) towards the preferred GGSN in the target network. This PDP context request will include the $GGSN_1$ address if this address has been provided by the user equipment. If this address has not been provided by the user equipment, $GGSN_2$ will fetch **225** (**525**; Fig. 5) the $GGSN_1$ address from the home location register (HLR) (**540**; Fig. 5) after receiving the unsolicited PDP context request from $SGSN_2$. $GGSN_2$ then initiates **230** a tunnel establishment procedure (e.g., IETF, ETSI GSM 9.60) towards $GGSN_1$. Buffering of data in the current serving network can be initiated by $SGSN_1$ (**530**; Fig. 5) after the unsolicited connection procedure has been completed. To complete the re-routing process, $GGSN_1$ updates the routing information **235** for the PDP context address and starts forwarding packets (**560**; Fig. 5) to $GGSN_2$. $GGSN_1$ additionally informs **240** $SGSN_1$ to remove PDP context data associated with the mobile terminal (**555**; Fig. 5).

Serving Network Initiated Handover (SNH)

In an exemplary GPRS based serving network initiated handover process shown in Fig. 3, the handover candidate cells are first determined **305** based on the signal quality measurement reports. Using a lookup database for the cells, the network identities (**625**;

Fig. 6) to which networks the candidate cells belong (if they are outside the serving network) are then retrieved **310**. A request is then sent to the current serving GGSN to initiate **320** an unsolicited PDP request to the corresponding candidate networks. The GGSN would first look up **315** the address for the point of attachment (POA) of these networks and then forward the unsolicited requests to the retrieved addresses. The transfer procedure begins before a target cell has been chosen by the equipment, therefore the transfer procedure/connection request will be sent to all GGSNs associated with any of the candidate cells. If any of the candidate cells could reside in the original network as well as in neighboring networks, a conventional intra-network procedure will be initiated at the same time as this new procedure. It may be possible that more than one point of attachment address is returned for one candidate network, in which case, the GGSN may choose to forward the request to all of them or to select only one address from the list.

Fig. 6 shows the scenario where two candidate networks (Candidate 2 **635** and Candidate 3 **630**) were selected and one point of attachment is returned per candidate network. The serving GGSN initiates an unsolicited PDP context request towards $GGSN_2$ **605** and $GGSN_3$ **610** which includes information such as the current RA (routing area) and the candidate RAs (RA_2 **615** and RA_3 **620** respectively). $GGSN_2$ **605** and $GGSN_3$ **610** would look up the corresponding SGSNs using the received candidate routing area information. Once the candidate GGSN's ($GGSN_2$ and $GGSN_3$) have looked up their corresponding SGSNs ($SGSN_2$, $SGSN_3$) associated with the candidate RAs, the unsolicited PDP context request is forwarded down to the SGSNs from the GGSNs in the candidate networks. For clarification, it is noted that the relationship between SGSN and GGSN may not be one to one. Many GGSNs could contact the same SGSN.

At step **325**, $SGSN_2$ and $SGSN_3$ determine if a routing area update has been received from the user equipment. If not, $SGSN_2$ and $SGSN_3$ will locate **330** the user equipment to request that the equipment respond to the locate with a routing area update. The user equipment decides to respond to the locate in RA_2 and responds with a routing area update message back to $SGSN_2$. Meanwhile $SGSN_3$ is informed that the user equipment is not reachable in RA_3 and informs $GGSN_3$ about the failure to reach the user.

$GGSN_3$ responds back to the serving GGSN that candidate Net_Id3 is not able to reach the user. The serving GGSN waits for the other responses to come back from the other candidate network. When $SGSN_2$ receives the routing area update message from the user equipment as a response to the locate, it will send **335** an unsolicited PDP context message back to $GGSN_2$. $GGSN_2$ then responds **340** to the request from $GGSN_1$ by establishing a path with $GGSN_1$. Only the first successful response from a candidate GGSN would be accepted, the rest would be discarded. After the path between $GGSN_1$ and $GGSN_2$ is established, $GGSN_1$ begins **345** forwarding Packet Data Units (PDU's) to $GGSN_2$. To complete the re-routing process, $GGSN_1$ informs **350** $SGSN_1$ to remove PDP context data associated with the mobile terminal.

<u>Terminal Assisted Handover (TAH)</u>

In an exemplary GPRS based terminal assisted handover process shown in Fig. 13, the user equipment (e.g., terminal) itself initiates the hand-off to the target network. Once the user equipment selects a target cell (**115**; Fig.1), the user equipment requests (**1300**; Fig. 13) access to the target network using, for example, an access handoff message. This request would include the type of service required, the quality of service, the session information, and the address of the GGSN of the network currently serving the user equipment (address of $GGSN_1$). In response to the access request from the user equipment, an unsolicited context request would be initiated **1305** from $SGSN_2$ in the target routing area towards $GGSN_2$ in the target network. The target network would then grant **1310** admission to the user equipment and secure resources to provide a connection with the equipment. The target network would further provide the address of the serving GGSN ($GGSN_2$) in the target network to the user equipment. The user equipment subsequently notifies **1315** the current serving $SGSN_1$/$GGSN_1$ of the equipment's readiness for handoff and supplies the address of $GGSN_2$. $SGSN_1$ requests $GGSN_1$ to buffer the data. The user equipment may also supply a new PDP address if provided by the target network.

In response to the notification from the user equipment, the serving $GGSN_1$ then starts forwarding **1320** data packets intended for the user equipment to the GGSN address ($GGSN_2$) provided by the user equipment. When the user equipment begins receiving data **1330** from the new channel established with the target network, the user equipment releases **1335** the old channel with the previous network.

Following completion of any of the three of the inter-GGSN packet re-routing techniques described above, an optional procedure for PDP context deactivation may be performed as shown in Figure 4. The method of Figure 4 may be initiated following the termination of Packet Data Unit (PDU) transfer from $GGSN_1$ to $GGSN_2$. In this exemplary method, $SGSN_2$ first initiates **400** a Detach procedure (**700**; Fig. 7) towards the user equipment, requesting that the terminal initiate Attach and PDP context activation procedures. The $SGSN_2$ then initiates **405** a Delete PDP context (705; Fig. 7) with the serving $GGSN_2$. In turn, the $GGSN_2$ initiates **410** a procedure to delete path establishment with $GGSN_1$.

Subsequent to the delete path procedure by $GGSN_2$, the user equipment begins **415** an Attach procedure (710; Fig. 7) towards $SGSN_2$, using conventional messaging such as, for example, that described in the GSM Standard 03.60. In response to the Attach request from the user equipment, $SGSN_2$ initiates **420** a location update request (**715**; Fig. 7) towards the HLR. The HLR then initiates **425** a location cancellation procedure (**720**; Fig. 7) towards $SGSN_1$. $SGSN_2$ then sends **430** an Attach accept message (**725**; Fig. 7) to the user equipment, which in turn responds by initiating **435** an Activate PDP context request (**730**; Fig. 7) towards $SGSN_2$. Subsequently, $SGSN_2$ initiates **440** a create PDP context request (**735**; Fig. 7) with $GGSN_2$. The user equipment or $SGSN_2$ may request a PDP context activation with $GGSN_1$ in certain circumstances such that $GGSN_2$ creates a hierarchical tunnel between $GGSN_2$ and $GGSN_1$. For example, the hierarchical tunnel may be created in the circumstance where a connection request cannot be satisfied by the current serving network.

Target Network Initiated Handover Using MobileIP

Another exemplary embodiment of the invention for providing seamless data communication between two packet networks is shown in Figures 8-11, with associated system messaging shown in Figure 12. In this solution to the problem of re-routing packet data when user equipment roams from a routing area administered by a first serving network to a routing area administered by a second serving network, it is assumed that the first and second serving networks communicate using MobileIP protocol. At step **800**, the user equipment first performs an attach procedure and requests PDP context activation (**1200**; Fig. 12) when registering in the first serving network ("Serving Network 1"). At step **810**, the user equipment acquires (**1205**; Fig. 12) the care-of address of the local foreign agent ($GGSN_1/FA_1/AAA_1$) in the first serving network from agent advertising messages that are broadcast by the foreign agent in accordance with conventional techniques. As shown at optional step **805**, the user equipment may alternatively acquire the foreign agent care-of address (FA COA) through modified system messages broadcast over the air interface.

After acquisition of the FA COA, the user equipment initiates **815** a MIP registration request (**1210**; Fig. 12) to the local foreign agent ($GGSN_1/FA_1/AAA_1$) in serving network 1. The MIP request would include a Network Access Identifier (NAI) that identifies the user equipment's home environment. The MIP registration request, however, may be included as an optional information element within the original PDP context Activation message from the user equipment so as to minimize the signaling sequence. If, though, the user equipment is not MIP capable, then the GGSN in the current serving network can assume the role of surrogate agent and initiate a MIP registration request after PDP context activation on behalf of the user equipment.

The FA_1/AAA_1 component of $GGSN_1$ then determines **820** that the registration request must be forwarded to the home environment identified by the NAI. FA_1/AAA_1 sends **825** the registration request (e.g., a DIAMETER message) (**1215**; Fig. 12) to the AAA server (AAA_{home}) in the home environment. If the registration request requests the assignment of a home agent, AAA_{home} will attempt to assign a home agent (HA3) from

the serving network if one is available and is capable of handling the load **900**. If one is not available, AAA_{home} will assign **905** a home agent in the home environment HA1. AAA_{home} then forwards **910** the MIP registration request (**1220**; Fig. 12) in an AAA message to HA3.

Upon receipt of the forwarded MIP registration request, HA3 validates **915** and stores binding information for the mobile terminal and then updates the routing table. HA3 then formulates a registration reply (**1225**; Fig. 12) and returns **920** it to the AAA_{home} server in the home environment. The AAA_{home} server returns **925** a response **1230** to the registration reply and the registration reply message is forwarded to the user equipment.

Subsequent to the above-described registration procedure, the user may roam to a new routing area serviced by a new SGSN ($SGSN_2$) in a network administered by a different service provider. The user equipment then performs **1000** a routing area update procedure (**1235**; Fig. 12), wherein the routing area parameters may include additional information such as the old foreign agent address and the current home agent address. The user equipment would then acquire **1005** the new FA COA from an unsolicited PDP context activation response (**1240**; Fig. 12) from the new foreign agent in the new GGSN. Optionally, the user equipment could acquire **1010** the FA COA in system broadcast messages.

The new SGSN ($SGSN_2$) then determines if MIP connectivity is required. If MIP connectivity is required, and is supported by $GGSN_2$, $SGSN_2$ initiates **1015** an unsolicited PDP context activation which may contain information regarding the old foreign agent, the current home agent, and the NAI. The activation request (**1245**; Fig. 12) would be sent to a pre-defined foreign agent such as GGSN2/FA_2/AAA_2. If roaming agreements between the provider of serving network 1 and the provider of serving network 2 permit, the new foreign agent FA_2 communicates (**1250**; Fig. 12) with the old foreign agent FA_1 to inform FA_1 that the user equipment is currently located within FA_2's service area. FA_2 then formulates **1025** a MIP registration request using the information received in the unsolicited PDP context activation and forwards the request (**1255**; Fig. 12) to AAA_{home}.

This MIP registration request may indicate that a new home agent be allocated. FA_2 will now be ready to receive forwarded packets.

After receipt of the MIP registration request from FA_2, the home environment AAA server forwards **1030** the request (**1260**; Fig. 12) to the home agent HA4 in serving network 2 to create binding information for the user equipment and to update the routing table. When a successful MIP registration reply is received, AAA_{home} notifies **1100** HA3 to remove the binding information if not currently in use. AAA_{home} then forwards **1105** the MIP reply answer (**1265**; Fig. 12) to FA_2 in an AAA message.

The above described exemplary embodiments describe inter-packet domain roaming in either GPRS or MobileIP networks. However, one skilled in the art will recognize that these exemplary techniques can be applied to any IP based communication protocol. For example, the exemplary embodiments describing inter-packet domain roaming using MobileIP protocol can be applied to other multi-media networks such as H.323 or SIP. The protocols currently defined in H.323 and SIP would need to be changed to include this functionality in accordance with the exemplary embodiments.

The above described exemplary embodiment describes how session mobility between two packet networks in a wireless system is achieved. A session, as is known today in the datacom world, is used to run one or more applications (e.g., voice over IP, web browsing). A session is transparent to the network layer, therefore when a user moves from one network to another, the session is unaware that the lower layers are reconfigured due to a new re-established connection. Session mobility involves a user having an active session on his/her user equipment and moves together with the equipment towards a new area served by a new network. The two networks cooperate in order to allow the user to continue working with his/her ongoing session.

Session mobility also involves a user having an open and active session running on his/her user equipment and moving without taking the equipment to another network (e.g., from work to home). The user, in the new network decides to connect to and continue with the same session through a different terminal. The exemplary embodiments described above could be used to allow for both scenarios. The second

scenario, however, allows for total network transparency and permits the user to connect to an ongoing session via another terminal located in a different network that may be wireless or fixed. For example, if a user is engaged in a session at a first terminal connected to a first network, the user may connect to a second terminal in a second network and the session may be re-routed, applying the exemplary embodiments described above, to the new terminal without loss of the ongoing session. Re-routing of the session may be achieved using a new user interface at the first terminal which prompts the user to enter the terminal to which the user is transferring. The input terminal information is then converted to a location (e.g., network entity address serving the terminal) of the new system by querying a local database (e.g., DNS).

Although a number of embodiments are described herein for purposes of illustration, these embodiments are not meant to be limiting. Those skilled in the art will recognize modifications that can be made in the illustrated embodiments. Such modifications are meant to be covered by the spirit and scope of the appended claims.